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Research Paper

Effects of built landscape on taxonomic homogenization: Two case studies of private gardens in the French Mediterranean

Angèle Bossu[a,*], Audrey Marco[b], Stéphanie Manel[a,c], Valérie Bertaudière-Montes[a]

[a] LPED "Laboratoire Population Environnement, Developpement" Aix Marseille University, IRD, UMR_D151, case 10, 3 place Victor Hugo, 1331 Marseille Cedex, France
[b] LAREP, Ecole Nationale Supérieure du Paysage (ENSP), France
[c] CIRAD, UMR AMAP, TA A51/PS2 34398 Montpellier Cedex 5, France

HIGHLIGHTS

- Landscape metrics influenced floristic similarity.
- Built-up density reduced floristic similarity between gardens.
- The effect of exotic species on floristic similarity depended of built-up density.
- Homogenization changed over time, due to historical soil seed bank and exotic species.

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ABSTRACT

Urbanization can promote the replacement of native species by exotic species resulting in an increase in community's similarity over time. This process is called biotic homogenization, which is usually studied at large scale from species lists. Our paper addresses the effects of urbanization on plant community at local scale in areas where urban policies are implemented. We focus on private gardens as they are the most common components of green spaces in European urbanized areas. They are also a place where exotic species are introduced. Observations were made on spontaneous flora sampled from gardens in two study sites of the French Mediterranean: a large city and a village located in an urbanizing rural area. We evaluated how urban landscape influences floristic similarity and how exotic species affect homogenization. We divided each study site in three built-up density zones. As the urbanization process of both sites did not take place at the same time, we were able to assess the effect of time on floristic similarity. Results indicate that floristic similarity is less important in high dense built-up areas than in low dense ones. Exotic species tend to reduce floristic similarity in city centers and increase floristic similarity in low dense built-up areas in both sites. Landscape metrics calculated in built-up areas surrounding the gardens influence floristic similarity. Lastly, we found that urban planning in terms of built-up density affects biodiversity distribution and that private gardens can provide landscape connectivity within urban areas.

1. Introduction

More than half of the world's population live in cities (Gaston, 2011; Veron, 2007) and this proportion is expected to rise up to 70% by 2050 (UN, 2012). This urban growth has led to urban sprawl, which is encroaching into rural areas on the fringes of large cities (Baccaïni & Semecurbe, 2009). The global urban area almost covered 0.5% of the world's total land area in 2000 and is expected to expand more than 12-fold between 2000 and 2050 (Angel, Parent, Civco, Blei, & Potere, 2011). With Spain and Portugal, South-East France (more precisely the Provence-Alpes Côte d'Azur region) is one of the most urbanized areas in Europe (EEA, 2006; Veron, 2007). The conversion of agricultural and semi-natural ecosystems into urban areas, especially for residential urban and suburban use, has represented the greatest human-driven source of landscape change during the 20th century. Urbanization in the French Mediterranean region has first spread along coastlines before expanding more

* Corresponding author at: LPED, Aix Marseille University, IRD, UMR_D151, case 10, 3 place Victor Hugo, 1331 Marseille Cedex, France. Tel.: +33 4 13 55 07 98.
E-mail addresses: angele.bossu@etu.univ-amu.fr (A. Bossu), a.marco@ecole-paysage.fr (A. Marco), stephanie.manel@univ-amu.fr (S. Manel), valerie.montes@univ-amu.fr (V. Bertaudière-Montes).

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recently through the hinterland, leading to a diffuse urban matrix made of individual or grouped houses scattered in the landscape (Daligaux, 2003). Small towns located in the hinterland (urbanizing rural areas) tend to reproduce the same urbanization patterns as the ones developed in urban large areas that are typically centered around a historical and dense downtown core and include a suburban residential area, detached houses built on former fields and a surrounding natural environment. In the last decade, an increasing housing density has been observed in urban fringe areas (Charmes, 2010). These drastic changes in land use confront us with issues on biodiversity change in urban areas.

One of these changes induced by urbanization is biotic homogenization (McKinney, 2006). It describes the process by which taxonomic similarity of biotas increases between sites (i.e. a decrease of β diversity) over time (Rahel, 2000). The change in taxonomic similarity is often due to an increase in exotic species and a decrease in native species. As highlighted by McKinney and Lockwood (1999), there is an increase in generalist species. This results in a community functional homogenization with a loss of specialist species (Olden, Poff, Douglas, Douglas, & Fausch, 2004).

The urban environment creates conditions that promote the adaptation of a great number of different species, particularly non-native ones (Kowarik, 2008; Shochat, Warren, Faeth, McIntyre, & Hope, 2006). Moreover, human settlements import non-native species for several reasons, ranging from the accidental importation by traffic associated with centers of commerce to the intentional importation of species for cultivation, pets, and other human uses (Mack & Lonsdale, 2001).

If the pool of non-native species that colonize cities is different between cities, then an opposite process can occur: biological differentiation (McKinney, 2004; Olden & Poff, 2003). In this case, the introduction of different species in different places will reduce similarity among communities over time (Olden et al., 2004; Qian, McKinney, & Kühn, 2008).

Given that homogenization is a process that occurs across time, historical data should be used to study the historical trends of similarity (Olden & Rooney, 2006). But these data are not available for our study. As a result, the effects of local extinctions will not be taken into account. By focusing on total flora, we can analyze current floristic similarity in order to not misuse the concept of homogenization. However, if we look at the effect of exotic flora on total similarity, it becomes possible to assess homogenization due to the role of exotic species.

Studies on homogenization have compared different sites or regions characterized by varying degrees of urbanization (Blair, 2001; Kuhn & Klotz, 2006; Schwartz, Thorne, & Viers, 2006) but have rarely been carried out at local scale although species replacement occurs at this scale. In general, the proportion of non-native species varies from less than a few percent in rural areas to over 50% in the urban core (McKinney, 2002). Given that urban habitat varies considerably in terms of the number of alien species it sustains and in its location along the rural–urban gradient (Chytrý et al., 2008; Lososová et al., 2012), the degree of biotic homogenization also differs (Lososová et al., 2012). We still have very little understanding of biotic homogenization across different built-up densities.

Several studies on landscape connectivity in urban areas have shown that the urban matrix affects the biodiversity and permeability found within the urban landscape (Caryl, Thomson, & van der Ree, 2013; Lizée et al., 2011; Werner, 2011). This landscape is made up of a multitude of habitat patches that are more or less isolated within an inhospitable matrix (Clergeau, Croci, Jokimaki, Kaisanlahti-Jokimaki, & Dinetti, 2006); this promotes the isolation of species. Buildings can play an important role in the dispersal of species in the urban landscape and their height and shape can generate important barriers (Fig. 1). Although landscape structure is known to impact processes like species connectivity (Taylor, Fahrig, & With, 2006), there still has never been any accurate description of landscape structures (aggregation index, fractal dimension, patch density, etc.) that further examines, for example, different types of residential urban areas to better understand local taxonomic similarity and therefore homogenization processes. Nevertheless, the similarity of communities can be affected not only by site conditions but also by movements of species, and therefore by the connectivity between areas.

Our interest is focused on floristic similarity of the entire spontaneous flora between private gardens to understand how it varies across the type of housing density and whether exotic species homogenize or differentiate floristic communities.

Private gardens are particularly appropriate for the study of floristic similarity and taxonomic homogenization because they are associated with spontaneous flora that can indicate land-use changes and gardening practices; they also remain a privileged place where exotic species are introduced (Bigirimana, Bogaert, De Cannière, Bigendako, & Parmentier, 2012; Marco et al., 2008; Pyšek, Jarošík, & Pergl, 2011; Smith, Thompson, Hodgson, Warren, & Gaston, 2006). Private gardens are widespread across European urbanized areas and contribute between 16 and 36% of the total urban area (Goddard, Dougill, & Benton, 2010); they can shed light on floristic similarity and homogenization from a spatial perspective. They can be found in different built-up density zones, thus providing a gradual approach to urbanization (habitat). Moreover, several studies have highlighted the need to study private gardens for their conservation potential (Goddard et al., 2010).

In this study, we compared the floristic similarity in private gardens located in different levels of built-up density along an urban gradient. Two sites were compared: an urban large area (850,000 inhabitants, surface area: 240 km^2) and a small town—an urbanizing rural area—(3700 inhabitants, surface area: 21 km^2). Both the urban large area and the small town are located in the same biogeographic context and have developed on calcareous soils and under the Mediterranean climate (Girerd & Roux, 2011). The two study sites have also experienced a similar urbanization relative to the expansion of individual housing but not at the same period. The delay observed in the urbanization process between the two study sites will be used to understand the effects of urbanization over time using a synchronic approach. We also analyzed the landscape factors that are likely to explain floristic similarity between private gardens. More specifically, we aim to address the following questions:

(i) Does floristic similarity between gardens change according to the urbanization gradient?
(ii) How do exotic species tend to change floristic similarity and induce homogenization?
(iii) How do landscape structure and garden characteristics explain similarities of spontaneous flora between private gardens?

2. Materials and methods

2.1. Study sites

This study was carried out in two sites: a small town (Lauris) and an urban large area (Marseille) located in south-eastern France, in the Mediterranean region. This area is characterized by a climate with summer drought, erratic rainfall throughout the year and mild winters (average minimum temperatures between 0 and 3 °C) (Joffre, Rambal, & Damesin, 2007).

Lauris (43°44′N, 5°18′E) is a village located within a regional natural park in the south of France. The village extends from the Petit Luberon massif to the Durance River within an area of 21 km^2. Like many other rural towns in the hinterland, Lauris has been